DRAFT

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Appendix E

Additional Information on Hook and Line Survey in Channel Islands National Marine Sanctuary

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Part I. Survey Overview

The Southern California Shelf Rockfish Hook and Line Survey's (hereafter, hook and line survey) primary objective is to provide an annual index of relative abundance and a time series of biological data for several key species of shelf rockfish (genus *Sebastes*) in the Southern California Bight (SCB). These indices and associated biological data provide key information for the development of stock assessments for several important species including bocaccio (*S. paucispinis*), vermilion rockfish (*S. miniatus*), sunset rockfish (*S. crocotulus*), greenspotted rockfish (*S. chlorostictus*) and cowcod (*S. levis*). These species are targeted largely by the recreational fishing community and are not well-sampled by trawl gear due to the complex bathymetry and hard-bottom habitats of the SCB they inhabit. The hook and line survey complements existing research conducted by NOAA Fisheries' Northwest Fisheries Science Center (NWFSC), including its annual coastwide bottom trawl survey and the acoustic survey for hake, as part of a suite of fishery-independent programs aimed at monitoring long-term trends in distribution and abundance of west coast groundfish.

The hook and line survey is a collaborative project among the NWFSC, Pacific States Marine Fisheries Commission, and the commercial passenger fishing vessel industry. The survey is conducted each fall aboard chartered sportfishing vessels and uses hook and line gear to sample untrawlable habitat throughout the SCB. Each year, 121 fixed sites are sampled, covering a depth range of 37–229 m. The sampling area is bounded by Point Arguello in the north (lat 34°30′N) and the border of the U.S.-Mexican exclusive economic zone in the south (lat 32°00′N). The sites are stratified by 20 different geographic areas to ensure sampling coverage throughout the SCB (Figure 1). In 2014, 42 new fixed sites were added to the sampling frame to provide preliminary survey coverage inside the two Cowcod Conservation Areas (CCAs). An additional 40 new sites are scheduled to be added in 2015 to provide synoptic coverage of the CCAs.

Figure 1. Location of 121 fixed sites (red triangles) within 20 subareas (white borders) sampled annually by the Hook and Line Survey

The survey is conducted using a fixed-point sampling design with specific locations defined by global positioning system (GPS) coordinates. Survey staff experimented with a random design during a 2003 pilot cruise; however, the distribution of suitable hard-bottom seafloor in the region is not sufficiently defined by habitat maps to support a stratified-random or reduced-random survey design without a significant increase in the amount of days at sea necessary to accommodate searching for appropriate target habitat. The fixed sites chosen for the sampling frame were compiled mainly from consultation with local sport and commercial fishermen and augmented with locations provided by California Department of Fish and Wildlife from historical monitoring programs and sites opportunistically sampled during previous hook and line cruises. Industry members provided input on a variety of historical fishing grounds throughout the region and gave their observations of the habitat types present and whether the productivity at these areas has changed over time. Using this information, a sampling frame was developed that included sites at a variety of depths, spatial areas, hard-bottom habitat types, and depletion levels.

Nineteen of the 20 sampling areas (Figure 1) contain between four and 13 sites based on the hypothesized (and later, observed) amount of target habitat in the area. The one exception is the Point Hueneme area, which currently contains only one site; other sites in this area were removed due to inappropriate habitat, and no others were added due to difficulty in locating replacements. Sites area assigned to the vessels such that over time, each site is sampled by each vessel approximately the same number of times. No formalized attempt was made to select sites according to depth stratification, although it was a consideration to include sites representing a variety of depths.

Sites are specific locations on the seafloor defined by GPS coordinates. A 100-yard radius around a site is provided to allow vessel captains flexibility in targeting the site given year-to-year changes in prevailing wind and ocean conditions. Sampling consists of three deckhands using rod and reel gear to make five coordinated drops of a vertically-arranged 5-hook sampling gangion, providing for a maximum possible catch of 75 fish per site. To assist in catch per unit effort analyses and modeling, deckhands use stopwatches to keep track of the soak time for each drop. The sampling rig consists of 5 shrimp flies on size 5/0 hooks baited with squid strips at 16-inch intervals and affixed to a 60 lb monofilament leader and gangion (Figure 2). The gangion is attached via a barrel swivel to an 80 lb Spectra mainline. Sinkers in one-pound intervals from 1 through 5 pounds are used as directed by the vessel captain based upon site depth and the prevailing wind and ocean conditions.

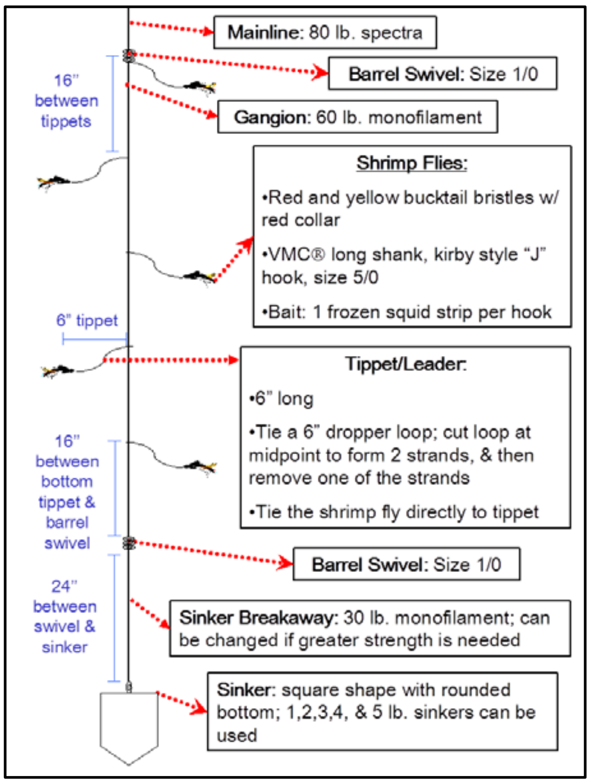


Figure 2. Schematic of the sampling gangion used during the hook and line survey

CPUE data and basic biological information are collected from all captured specimens. Rockfish species are sacrificed, and length, weight, sex, age (via otolith extraction), and genetic (via fin clip) information is collected. The DNA analyses focus on confirming species identification, determining stock structure, and separating cryptic species including vermilion and sunset rockfishes (e.g., Hyde et al. 2008). Additional organ and tissue samples are collected on an opportunistic basis to facilitate research on into the maturity, diet, and trophic ecology of demersal rockfish species. Most non-rockfish species captured by the survey lack physoclistous swim bladders and are less prone to barotrauma; hence they are generally returned alive to the sea at the surface after basic biological data are collected. Quantitative and qualitative information on oceanographic and weather conditions is also collected by sensor deployment and observation.

Through 2014, the survey has compiled an 11-year annual time series of catch per unit effort (CPUE) and biological data for groundfish species in the SCB region. Since 2004, 53 different species of fish have been caught by the survey, including 37 species of rockfish (Table 1).

Table 1. All species encountered during the hook and line survey, 2004-2014.

Common Name	Scientific Name
Bank Rockfish	*Sebastes rufus*
Barred Sand Bass	*Paralabrax nebulifer*
Blackgill Rockfish	*Sebastes melanostomus*
Blue Rockfish	*Sebastes mystinus*
Bocaccio	*Sebastes paucispinis*
Bonito (Eastern Pacific)	*Sarda chiliensis chiliensis*
Bronzespotted Rockfish	*Sebastes gilli*
Brown Rockfish	*Sebastes auriculatus*
Brown Smoothhound	*Mustelus henlei*
Calico Rockfish	*Sebastes dalli*
California Lizardfish	*Synodus lucioceps*
California Scorpionfish	*Scorpaena guttata*
California Sheephead	*Semicossyphus pulcher*
Canary Rockfish	*Sebastes pinniger*
Chilipepper	*Sebastes goodei*
Copper Rockfish	*Sebastes caurinus*
Cowcod	*Sebastes levis*
Flag Rockfish	*Sebastes rubrivinctus*
Freckled Rockfish	*Sebastes lentiginosus*
Gopher Rockfish	*Sebastes carnatus*
Gray Smoothhound	*Mustelus californicus*
Greenblotched Rockfish	*Sebastes rosenblatti*
Greenspotted Rockfish	*Sebastes chlorostictus*
Greenstriped Rockfish	*Sebastes elongatus*
Halfbanded Rockfish	*Sebastes semicinctus*
Honeycomb Rockfish	*Sebastes umbrosus*
Lingcod	*Ophiodon elongatus*
Mexican Rockfish	*Sebastes macdonaldi*
Ocean Whitefish	*Caulolatilus princeps*
Olive Rockfish	*Sebastes serranoides*
Pacific Jack Mackerel	*Trachurus symmetricus*
Pacific Chub Mackerel	*Scomber japonicus*

Common Name	Scientific Name
Pacific Sanddab	*Citharichthys sordidus*
Petrale Sole	*Eopsetta jordani*
Pink Rockfish	*Sebastes eos*
Pinkrose Rockfish	*Sebastes simulator*
Rosethorn Rockfish	*Sebastes helvomaculatus*
Rosy Rockfish	*Sebastes rosaceus*
Sharpchin Rockfish	*Sebastes zacentrus*
Silvergray Rockfish	*Sebastes brevispinis*
Southern Rock Sole	*Lepidopsetta bilineata*
Speckled Rockfish	*Sebastes ovalis*
Spiny Dogfish	*Squalus suckleyi*
Squarespot Rockfish	*Sebastes hopkinsi*
Starry Rockfish	*Sebastes constellatus*
Swordspine Rockfish	*Sebastes ensifer*
Treefish	*Sebastes serriceps*
Vermilion Rockfish	*Sebastes miniatus*
White Croaker	*Genyonemus lineatus*
Widow Rockfish	*Sebastes entomelas*
Yelloweye Rockfish	*Sebastes ruberrimus*
Yellowtail Rockfish	*Sebastes flavidus*

A towed underwater video system is also used during portions of the cruises to gather visual footage of the seafloor habitat as well as any demersal fish and invertebrates present. These visual observations are used to improve our knowledge of the various bottom types at each sampling site, identify locations of important invertebrate colonies, and help develop and test hypotheses about fish and habitat interactions.

Part II. Impacts on Channel Island National Marine Sanctuary Resources

Identification of sanctuary resources and values that may be affected

All sampling on the hook and line survey is conducted within the SCB, ranging from Point Arguello in the north (34º 35’ N) to 60 Mile Bank in the south (32º 00’ N), in waters from 20 fathoms (37 m) to 125 fathoms (229 m) and includes the two Cowcod Conservation Areas (CCAs) (Harms et al. 2008). All sampling activities occur within the U.S. Exclusive Economic Zone. Six of the survey’s original 121 fixed stations (sites 180, 184, 048, 228, 229, and 413) occur within the Channel Islands National Marine Sanctuary (CINMS) Marine Protected Areas (MPAs) – 2 within the Richardson Rock Federal MPA (sites 180 and 184, Figure 3a) and 4 within the Footprint Federal Reserve (sites 048, 228, 229, and 413, Figure 3b). All research catch at all stations is accounted for in the Pacific Fishery Management Council’s (PFMC) Total Allowable Catch limits for each species established as per the Magnuson-Stevens Sustainable Fisheries Act.

a)

b)

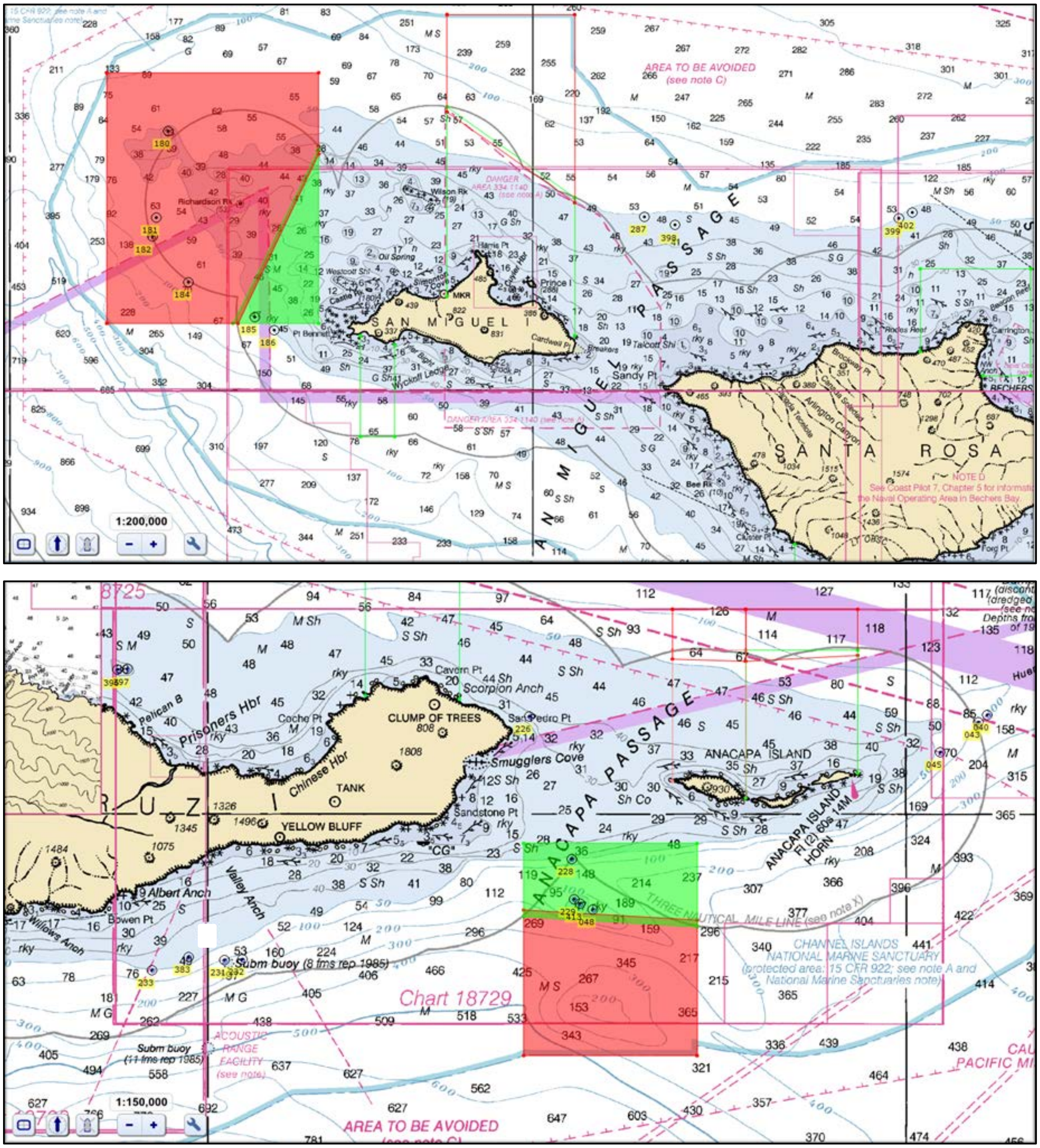


Figure 3. Hook and Line stations within the a) Richardson Rock Federal MPA (stations 180, and 184) and b) the Footprint Federal MPA (stations 048, 228, 229, and 413)
Although the green and red colors represent the corner coordinates used to demarcate the state and federal reserves, all sites within the Footprint MPA (1b) are actually in federal waters.

The hook and line survey's time series at stations inside both the Richardson Rock and Footprint MPAs began in 2004, prior to the implementation of the federal reserves in 2007 and 2008. The two Richardson Rock sites have been sampled 9 – 10 times from 2004 to 2014 and each of the four Footprint sites have been sampled 8 to 11 times over the same 11 year period. Sites have been missed primarily due to weather. Table 2 shows the location and number of times throughout the survey period (2004 – 2014) that the sites within the federal MPAs have been sampled.

Table 2. Hook and line survey sites within federal MPAs in the CINMS: latitude, longitude and total number of visits to each site 2004–2014

Site	Latitude	Longitude	Times sampled
180	34° 08.5'	120° 33.9'	10
184	34° 03.5'	120° 33.2'	9
48	33° 57.7'	119° 29.0'	11
228	33° 58.9'	119° 29.6'	8
229	33° 57.9'	119° 29.5'	10
413	33° 57.8'	119° 29.3'	8

The hook and line survey has encountered 24 fish species within the two CINMS MPAs during the period 2004-2014 which includes the cryptic species pair vermilion rockfish (*Sebastes miniatus*) and sunset rockfish (*S. crocotulus*) (Hyde et al., 2008). Virtually indistinguishable in the field, the vermilion rockfish complex is an integral component of the region's sportfishing sector and, collectively, is the state of California's 2nd most commonly landed species of groundfish among recreational anglers (RecFIN extracted 27 February 2014). Vermilion and sunset rockfish are separately identified based on DNA analysis at the conclusion of each annual survey. The hook and line survey is currently the only means of tracking the abundance of the complex's two constituent species.

Table 3 provides information on all species encountered at the 6 MPA sites within the CINMS during the period 2004-2014 including whether the species is primarily pelagic or demersal in habitat association. Also shown in the table are the total catch (summed across the 6 sites and 11 years of the survey) and the average annual catch for each species, adjusted for years when a site may have been missed due to weather. The final column in the Table 3 is, therefore, the species-specific, expected annual impact of continuing the hook and line survey within the MPAs at the Richardson Rock and Footprint sites. The expected annual impact ranges from a removal of 0.09 to 48.88 fish yr^{-1}, depending on species, or an average total catch of approximately 163 fish of all species for the 6 MPA sites. This is equivalent to the take of approximately 27 fish per year at each of the 6 MPA sites.

Table 3. Common and scientific names, habitat, total catch (individuals) and expected average catch per year (average yr^{-1} adjusted for years where not all sites were sampled) over the survey period (2004-2014) for species encountered in CINMS federal MPAs

Common Name	Scientific Name	Habitat	Total (n)	Expected avg yr^{1}(n)
Vermilion Complex	*Sebastes miniatus spp.*	demersal	445	48.88
Bocaccio	*Sebastes paucispinis*	demersal	440	48.17
Greenspotted Rockfish	*Sebastes chlorostictus*	demersal	95	9.82
Blue Rockfish	*Sebastes mystinus*	demersal	82	8.20
Speckled Rockfish	*Sebastes ovalis*	demersal	63	6.85
Lingcod	*Ophiodon elongatus*	demersal	66	6.55
Yellowtail Rockfish	*Sebastes flavidus*	demersal	49	5.40

Common Name	Scientific Name	Habitat	Total (n)	Expected avg yr[1](n)
Starry Rockfish	*Sebastes constellatus*	demersal	49	5.15
Pacific Mackerel	*Scomber japonicus*	pelagic	41	5.13
Chilipepper	*Sebastes goodei*	demersal	34	3.78
Olive Rockfish	*Sebastes serranoides*	demersal	36	3.60
Rosy Rockfish	*Sebastes rosaceus*	demersal	25	2.90
Swordspine Rockfish	*Sebastes ensifer*	demersal	16	1.58
Copper Rockfish	*Sebastes caurinus*	demersal	11	1.23
Flag Rockfish	*Sebastes rubrivinctus*	demersal	10	1.20
Widow Rockfish	*Sebastes entomelas*	demersal	10	1.04
Halfbanded Rockfish	*Sebastes semicinctus*	demersal	10	1.00
Sanddab unidentified	*Citharichthys spp.*	demersal	7	0.78
Squarespot Rockfish	*Sebastes hopkinsi*	demersal	6	0.63
Yelloweye Rockfish	*Sebastes ruberrimus*	demersal	5	0.50
Canary Rockfish	*Sebastes pinniger*	demersal	3	0.33
Bonito	*Sarda chiliensis*	pelagic	1	0.13
Greenstriped Rockfish	*Sebastes elongatus*	demersal	1	0.09

The actual number of fish sampled at each MPA site varies by location and year (Table 4). In general, more fish are encountered within the Richardson Rock MPA (average catch 35 – 45 fish yr^{-1}) than the Footprint MPA (average catch 12 – 18 fish yr^{-1}) with the range within MPAs varying from 1 – 70 fish yr^{-1} across years (Table 4).

Table 4. Total catch of all species within each of the 6 CINMS MPAs by year (2004-2014).

The minimum, maximum, and average catch within the study period are also shown. "NS" indicates a site was not sampled in a particular year.

	Site (reserve)					
Year	**180 (RR)**	**184 (RR)**	**48 (F)**	**228 (F)**	**229 (F)**	**413 (F)**
2004	24	NS	21	4	NS	NS
2005	44	66	40	NS	12	NS
2006	NS	NS	11	NS	7	3
2007	53	56	5	NS	1	1
2008	55	70	4	18	12	11
2009	42	60	12	10	10	7
2010	41	55	5	23	16	2
2011	56	66	21	33	20	46
2012	42	55	4	8	21	28

	Site (reserve)					
Year	**180 (RR)**	**184 (RR)**	**48 (F)**	**228 (F)**	**229 (F)**	**413 (F)**
2013	11	25	9	51	13	NS
2014	19	39	26	55	20	36
Minimum	11	25	4	4	1	1
Maximum	56	70	40	55	21	46
Avg catch	38.7	54.7	14.4	25.3	13.2	16.8

Assessment of the nature and likelihood of direct and cumulative effects.

To better understand the effects of survey-induced mortality on the resources within the Richardson Rock and Footprint federal reserves, we used observed survey catch rates to estimate total abundance first within the two MPAs, and then again at the larger CINMS level. We then examined the relative impact of survey take inside the MPAs compared to estimated overall abundance within the entire CINMS.

To estimate the total abundance of each species encountered by the survey within the two federal reserves, we used observed survey CPUE (n site^{-1}) at the 6 reserve sites for the taxa listed in Table 3 (22 species and one species complex). We then calculated the area sampled at each site (radius = 91.4 m; site area = 26,267.9 m^2 or 0.026268 km^2 per site or 0.15761 km^2 for all 6 sites in the reserves). The CPUE data were then converted to species-specific density estimates for each site (n km^2). Because the species targeted and captured by the hook and line survey are generally associated with hard bottom, we needed to estimate the proportion of hard bottom within the CINMS. The most recent Essential Fish Habitat Review (EFH) (PFMC, 2012) estimated approximately 6% of the seafloor area within the CINMS contains hard substrate, and another 14% of the seafloor area was designated as either unknown or a mix of hard and soft bottom habitats. Because of the uncertainty around the relative mix of hard, soft, and unknown bottom habitats, we assumed 50% of the ambiguously-classified habitat is actually hard substrate, bringing the estimated proportion of hard bottom habitat within the CINMS to 13%. This is likely a conservative estimate based upon preliminary analysis comparing visual observations from NWFSC camera sled deployments in the SCB with EFH maps (Chappell, A.C., 2014, unpublished research). We then used the rate of change of observed catch rates by drop at all 26 sites within the CINMS to estimate a catchability coefficient (q) of 0.12. Finally, we assumed a constant size selectivity of 1.0 (e.g., all individuals of all species are 100% vulnerable to the survey gear regardless of their size) which is a conservative assumption. Using these parameters, estimated total abundances aggregated for both the Richardson Rock and Footprint MPAs are presented in Table 5. The lowest abundances calculated are 47 for greenstriped rockfish and 65 for bonito. The estimates for greenstriped rockfish (often associated with soft substrate) and bonito (a generally pelagic species) are likely to be significant underestimates of true abundance within the reserves due to the survey's emphasis on sampling hard bottom habitats. Estimated abundances are significantly higher for key target species which are primarily associated with hard substrates such as the vermilion rockfish complex (n=25,300) and bocaccio (n=24,932). Expected annual catch of bocaccio at the 6 MPA sites relative to its estimated combined abundance in the Richardson Rock and Footprint MPAs as well as annual expected natural mortality due to predation and senescence (M_{inst}=0.15 converted to an annual value for M of approximately 0.139) is shown in Figure 4.

Table 5. Expected annual catch, estimated total abundances, and relative impacts of hook and line survey catch within the CINMS and its MPAs

Species	Expected avg annual catch in RR and Footprint MPAs (n yr^{-1})	Estimated total abundance in RR and Footprint MPAs (n)	Estimated total abundance in CINMS (n)	Relative impact: ratio of annual survey take in MPAs relative to total abundance in CINMS	
				Ratio	%
Blue Rockfish	8.20	4,244	160,698	5.10E-05	0.0051%
Bocaccio	48.17	24,932	919,869	5.24E-05	0.0052%
Bonito	0.13	65	755	1.66E-04	0.0166%
Canary Rockfish	0.33	173	11,960	2.79E-05	0.0028%
Chilipepper	3.78	1,955	50,207	7.52E-05	0.0075%
Copper Rockfish	1.23	634	217,985	5.62E-06	0.0006%
Flag Rockfish	1.20	621	15,027	7.99E-05	0.0080%
Greenspotted Rockfish	9.82	5,082	428,418	2.29E-05	0.0023%
Greenstriped Rockfish	0.09	47	10,042	9.05E-06	0.0009%
Halfbanded Rockfish	1.00	518	20,477	4.88E-05	0.0049%
Lingcod	6.55	3,392	137,874	4.75E-05	0.0048%
Olive Rockfish	3.60	1,863	68,903	5.22E-05	0.0052%
Pacific Mackerel	5.13	2,653	34,901	1.47E-04	0.0147%
Rosy Rockfish	2.90	1,501	47,549	6.10E-05	0.0061%
Sanddab Unidentified	0.78	401	49,062	1.58E-05	0.0016%
Speckled Rockfish	6.85	3,546	119,474	5.74E-05	0.0057%
Squarespot Rockfish	0.63	323	23,542	2.65E-05	0.0027%
Starry Rockfish	5.15	2,668	82,415	6.25E-05	0.0063%
Swordspine Rockfish	1.58	819	22,961	6.89E-05	0.0069%
Vermilion Complex	48.88	25,300	1,829,628	2.67E-05	0.0027%
Widow Rockfish	1.04	539	78,505	1.33E-05	0.0013%
Yelloweye Rockfish	0.50	259	5,380	9.29E-05	0.0093%
Yellowtail Rockfish	5.40	2,795	167,632	3.22E-05	0.0032%

We then used observed catch rates at all 26 sites in the CINMS (Figure 5) and employed the same methodology to estimate absolute abundance for the same 23 taxa in the CINMS as a whole (3,807 km^2). The last column in Table 5 provides an annual, species-specific relative impact of survey take by calculating the ratio of the average expected annual catch to the total estimated abundance within the entire CINMS. This information is also shown in Figure 6 sorted by decreasing relative impact and indicates that catch of bonito (a pelagic species captured only in the MPAs and not elsewhere in the CINMS and unlikely to be a permanent resident of the MPAs) is expected to have the greatest impact on CINMS resources with .0166% of the individuals in the region removed. Catch of the most abundant taxon within the CINMS (vermilion rockfish complex) is expected to have a much lower relative impact, with .0027% of the individuals in the region removed by the hook and line survey. The lowest relative impact was estimated for copper rockfish with .0006%) of the individuals taken in the CINMS removed from the 6 MPA sites. We believe any adverse effects on Sanctuary resources resulting from these low levels of mortality to be generally negligible at both the MPA and CINMS scales.

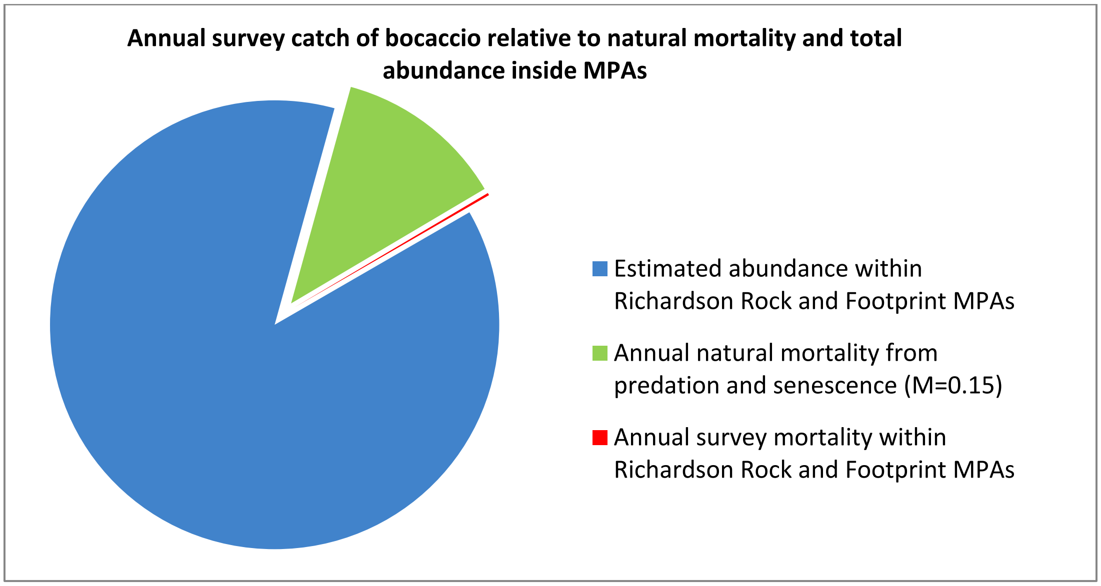


Figure 4. Ratio of expected average annual catch of bocaccio at the 6 federal MPA sites (red slice) relative to estimated removals due to natural mortality (calculated from M_{inst}=0.15; green slice) and estimated total abundance of bocaccio within the Richardson Rock and Footprint reserves (blue slice).

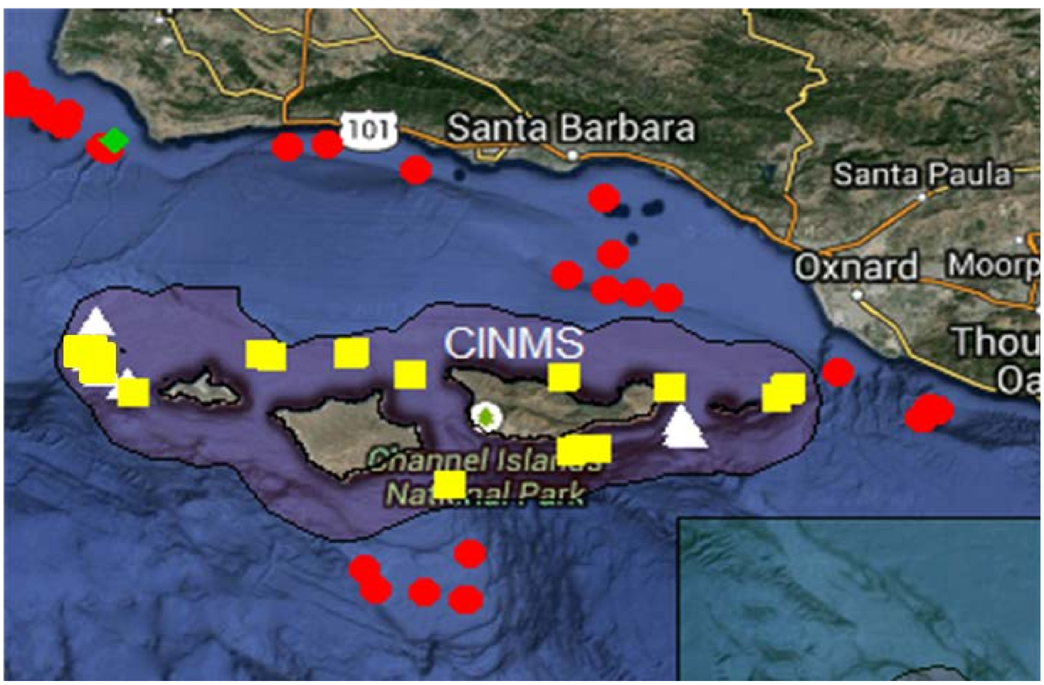


Figure 5. Location of all 26 hook and line survey sites within the CINMS.
White triangles are within federal MPAs, and yellow squares are within the CINMS but outside federal MPAs. Red circles are adjacent stations located outside of the CINMS.

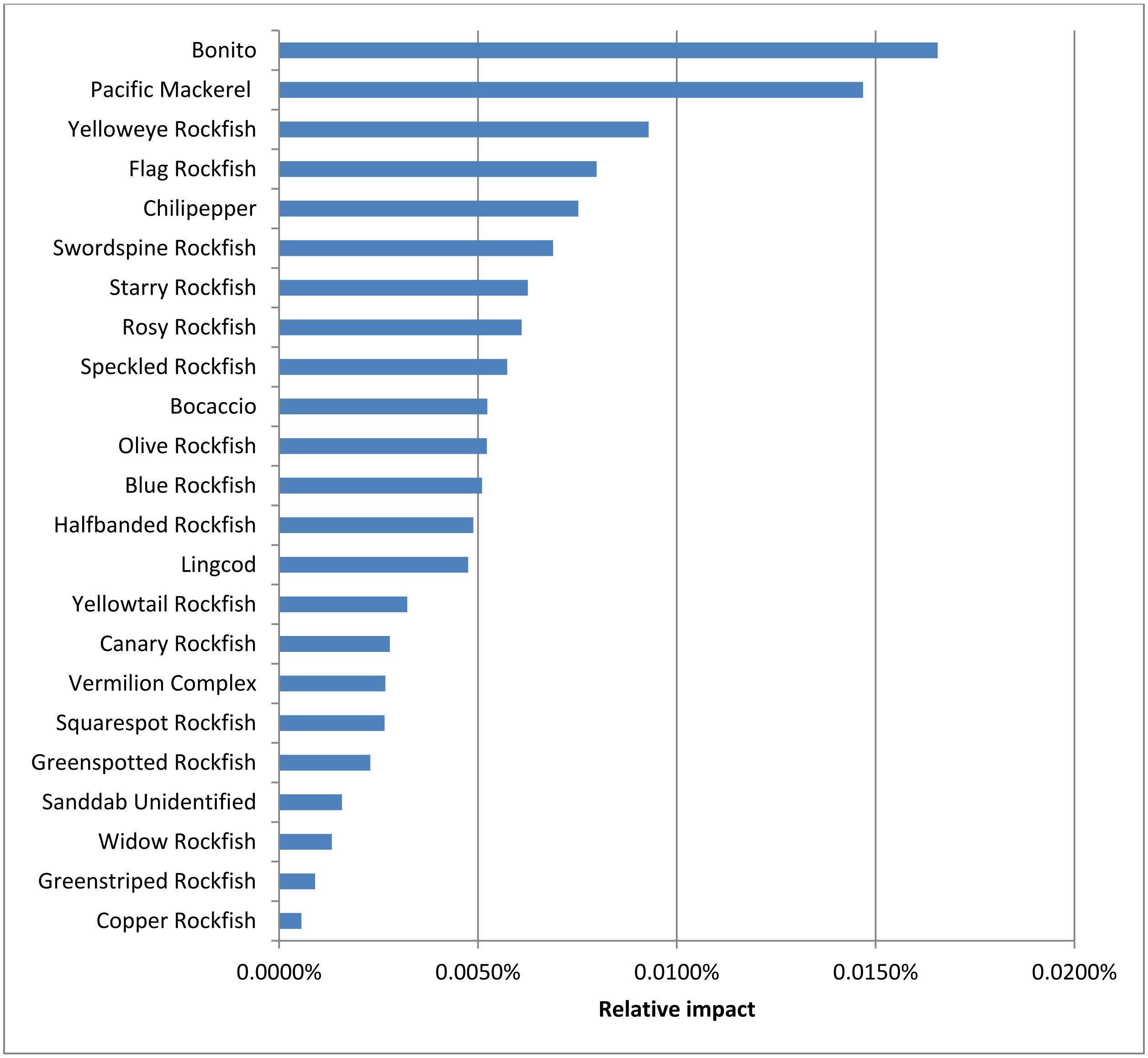


Figure 6. Relative impact of the hook and line survey on CINMS resources (i.e. ratio of average expected annual catch in the Richardson Rock and Footprint MPAs as a ratio of total abundance within the entire CINMS).

To investigate whether the hook and line survey might be causing localized depletion within MPAs, we compared the trend over time for catch of 23 taxa within the federal MPAs to the catch of the same species outside the federal MPAs from 2004-2014 (Figure 7). No discernible trend in abundance is readily apparent from within the MPA sites, but the data are not suggestive of survey-induced depletion. Catches at sites inside the CINMS but outside the federal reserves do suggest a slight decreasing trend over time which may be influenced by different population dynamics elsewhere in the CINMS, continued legal access to these areas by sport and commercial fishermen, or other factors.

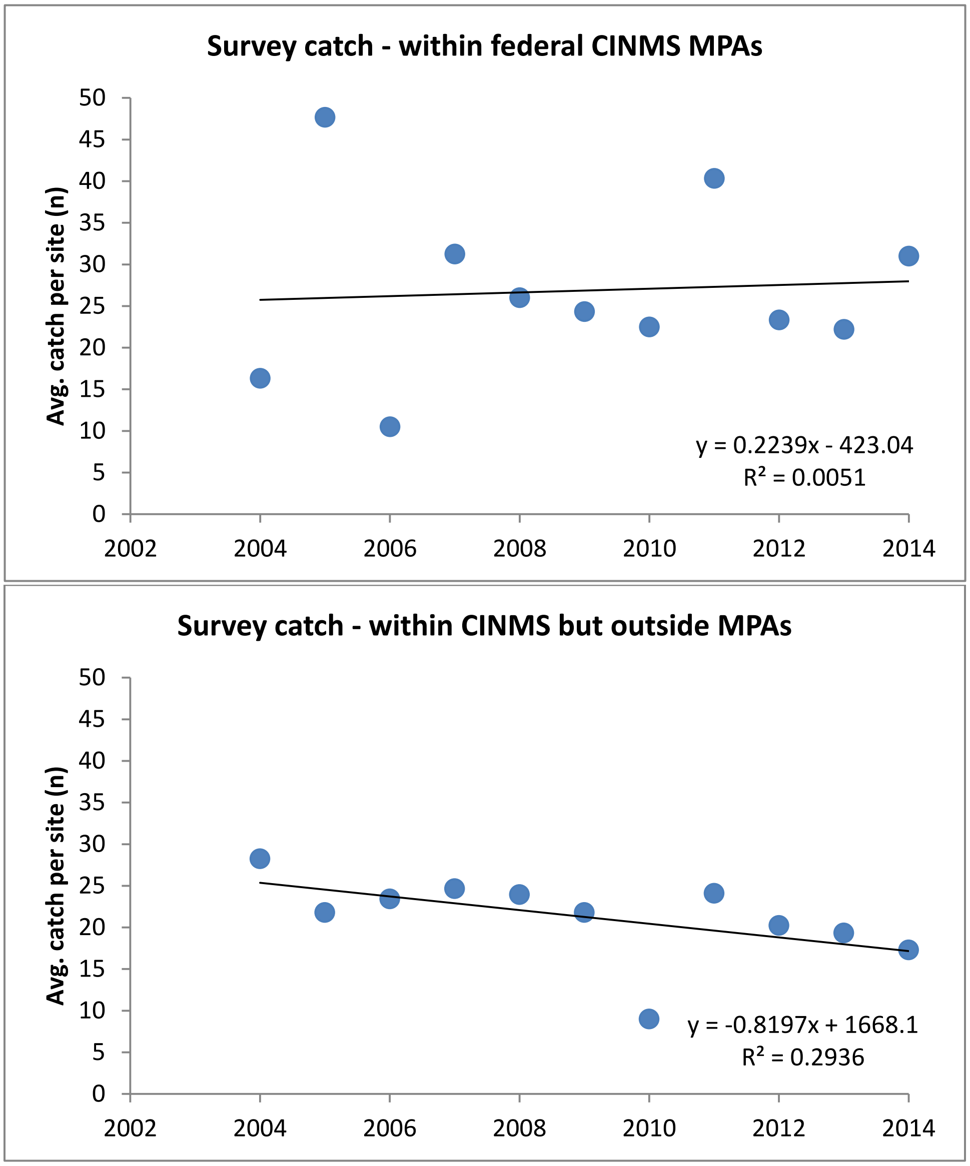


Figure 7. Average combined catch per site of 23 fish taxa by year during the hook and line survey within CINMS federal MPAs (upper panel) and inside the CINMS but outside federal MPAs (lower panel).

Assessment of the nature and likelihood of indirect effects

The potential direct effects were described above based on the known catch within the MPAs over the history of the hook and line survey. One indirect effect that is of potential concern is survey-induced mortality of older, larger fish. To investigate this, we compared the size (length, cm) of two abundant taxa (vermilion rockfish complex and bocaccio) within and outside the CINMS reserves. The boxplots in Figure 8 show the length distribution for the two species. For both species, the mean (asterisk) and median (bolded line) are larger within the reserves than at non-reserve sites within the CINMS. The data also indicate a larger spread of sizes at the non-reserve sites, as well as a lack of smaller fish inside the reserves suggesting the reserves may be serving as a repository for larger, older fish and are not being disproportionately removed via survey mortality. This is consistent with findings from other studies that indicate an association between protected areas and an increase in the average size of fish (Harmelin et al. 1995; Piet and Rijnsdrop, 1998; Tetreaut and Ambrose, 2007; Jaworski et al., 2010; Keller et al., 2014).

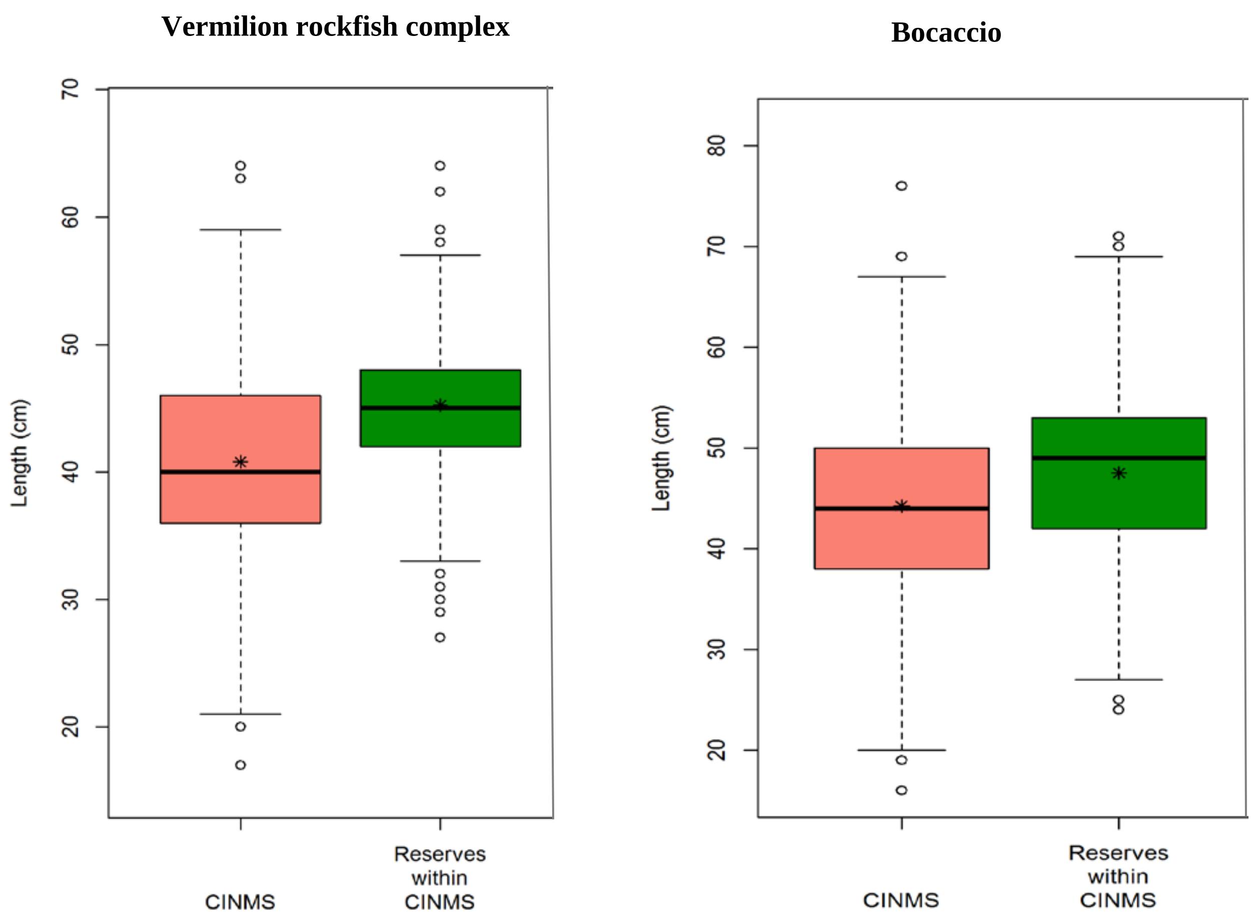
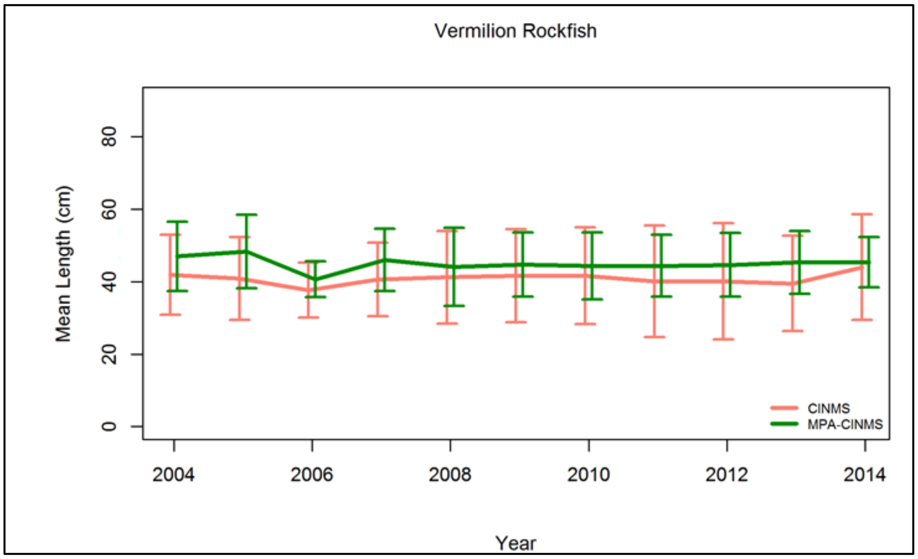


Figure 8. Boxplots of length (cm) for vermilion complex and bocaccio from sites within and outside the CINMS MPAs.
Asterisks indicate mean length and the bold horizontal lines indicate median length.

To determine whether mean length might be decreasing over time inside the reserves, we next compared mean length (cm) within and outside the CINMS MPAs by year for the same two species (Figure 9). Although there is a large amount of variability in the data, there is no readily apparent trend over time, and the mean length for both species is consistently higher inside the reserves than out. These analyses suggest the survey is not measurably reducing the amount of larger, older fish from sites inside or outside of the reserves, and that any adverse effect is short-term in duration.



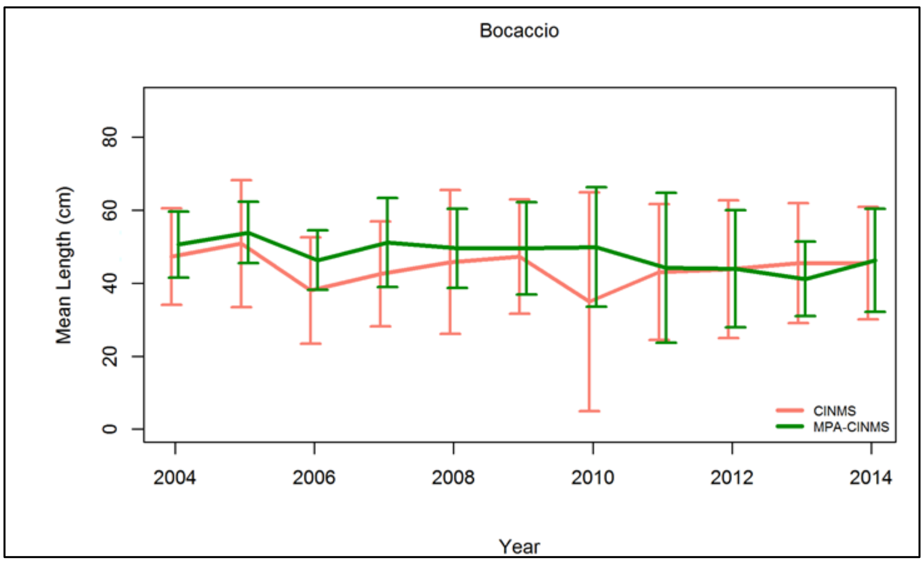


Figure 9. Mean length (cm) by year for vermilion rockfish and bocaccio within and outside the CINMS MPAs.
Error bars represent +2 standard deviations of observed lengths on each side of the mean length.

To examine the statistical impact of removing the federal and state MPAs from the suite of survey sites used to generate abundance indices for stock assessments, we developed standardized indices of abundance for three species with high catch rates inside the CINMS: bocaccio, vermilion rockfish complex, and yellowtail rockfish both with and without the MPA sites included in the models (Harms et al. 2010). Removing the federal MPA sites from the bocaccio analysis resulted in an average increase of 9.6% in the size of the 95% confidence intervals and an 18.6% increase when both the federal and state MPAs are removed from the analysis (Figure 10). For the vermilion rockfish complex, removing the federal MPA sites from that analysis resulted in an average increase of 0.7% in the size of the 95% confidence intervals and a 2.5% increase when both the federal and state MPA's are removed (Figure 11). More striking, for yellowtail rockfish, removing the federal MPA sites from that analysis resulted in an average increase of 126.8% in the size of the 95% confidence intervals and an 886.2% increase when both the federal and state MPA's are removed (Figure 12). Note that for the scenario of removing only the federal MPA sites for yellowtail rockfish, the large confidence intervals only appear for 2013-14 survey years. This corresponds to years where three vessels were used for the survey as compared to two vessels in the other years; hence it suggests that the model is responding with increased uncertainty to the relatively small number of yellowtail rockfish observations within some strata for those years. When both federal and state MPAs are removed from the analysis, this holds true for all years.

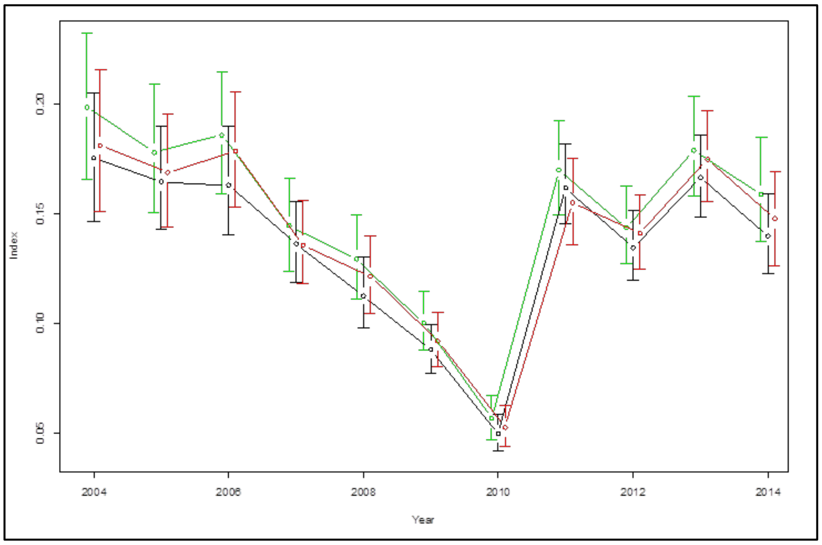


Figure 10. Bocaccio model index (black line) with 95% confidence limits.
The final model without the federal MPA sites in the CINMS is shown in red, and the final model without the federal and state MPA sites is shown in green.

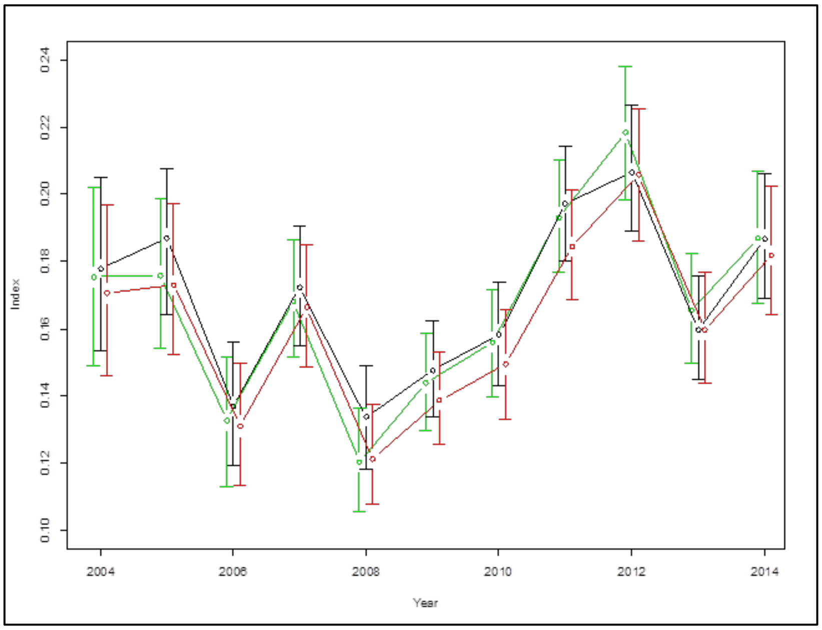


Figure 11. Vermillion rockfish complex model index (black line) with 95% confidence limits.
The final model without the federal MPA sites in the CINMS is shown in red, and the final model without the federal and state MPA sites is shown in green.

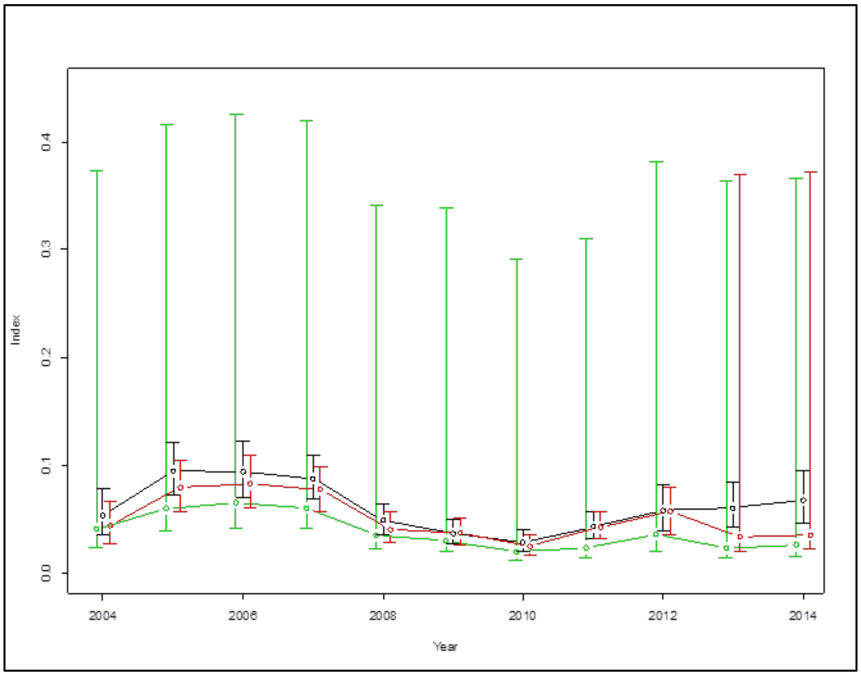


Figure 12. Yellowtail rockfish model index (black line) with 95% confidence limits.
The final model without the federal MPA sites in the CINMS is shown in red, and the final model without the federal and state MPA sites is shown in green.

The indices suggest that using a reduced number of sites, in all cases, resulted in more variable indices both within year and across years. However, different trends are observed for the different sets of data, suggesting that the species are utilizing various areas within the CINMS and its reserves differently, and it is important to monitor all sites when an index of the entire stock is desired. Reducing the uncertainty surrounding the population dynamics inside of areas closed to fishing was the underlying rationale cited by the PFMC and assessment authors for recommending the initiation of hook and line survey sampling within the two Cowcod Conservation Area reserves which had been closed to both fishing and fishery-independent surveys since 2000 (PFMC, 2013).

Documentation and permitting

Complete survey data are available upon request from the NWFSC. For the 2015 hook and line survey scheduled to begin in September 2015, we have obtained CDFW Scientific Collecting Permit (no. SC-11678) and are in the processing of obtaining a federal Scientific Research Permit (SRP-01b). In addition, all research catch is accounted for in the PFMC's Total Allowable Catch limits established as per the Magnuson-Stevens Sustainable Fisheries Act.

Part III. Mitigation Plan

The NWFSC is working in collaboration with the CINMS to minimize impacts at survey sites that occur within marine reserves. These measures include evaluating the impacts and feasibility of removing or re-locating existing survey sites currently inside reserves, short-term, immediate reductions in mortality, and using barotrauma-reduction descending devices to return captured fish alive to the seafloor.

Removal of site(s), and transition to site(s) outside the MPA

The NWFSC is interested in exploring whether one or more existing survey sites may be removed from the reserves through a calibration process with a new, paired site. Site 180 is located just inside the Richardson Rock MPA boundary. We propose establishing a paired site just outside the MPA that is similar in habitat, depth, and related features to site 180. We will then sample the two sites in parallel for a 10-year period to facilitate a calibration analysis. If both the CINMS and NFWSC deem the calibration suggests that the new site yields data that is sufficiently consistent with the data from site 180, the latter site will be removed from the sampling frame. To support this effort, we propose the following steps:

- Summer 2015 – Work with sanctuary staff and industry partners to identify one or more sites outside the Richardson Rock MPA that is similar to site 180 in habitat, depth, and related features.
- Fall 2015 – Begin sampling new site(s).
- 2016-2024 (annually) – The two sites will be sampled in parallel during the annual hook and line survey. The CINMS and NWFSC will statistically evaluate the suitability of incorporating the new site(s) into the time series. Jointly, NWFSC and CINMS will determine whether the new site is a suitable replacement for site 180.
- 2025 – Final decision for inclusion/exclusion of site 180, if it has not been made earlier.

Immediate reductions in survey mortality within federal MPAs

The NWFSC understands the immediate need to minimize survey impacts in marine reserves. Hence we propose for the 2015 survey a reduction in the number of drops from 5 to 3 at sites 180, 184, 048, 228, 229 and 413 providing an immediate 40% reduction in effort (and consequently, mortality) within the Footprint and Richardson Rock federal MPAs. In addition to reducing survey take within MPAs, this approach allows for the continuation of the survey's established and standardized sampling protocols and maintains the viability of the survey's historical time series at these sites until additional mitigation measures are implemented (see below). One caveat with this approach is that the reduction in survey effort will be accompanied by a proportional decrease in our ability to detect changes in abundance, species composition, and other quantities of interest. For this effort, we propose the following steps:

- Fall 2015 – reduce sampling in all 6 federal MPA sites from 5 drops to 3
- Annually thereafter – present mortality data inside and outside CINMS reserves to CINMS staff. The NWFSC and CINMS will jointly determine whether changes in sampling effort are appropriate for each subsequent year.

Use of descending devices

We will research and deploy descending devices in a manner that will ensure not only reduced survey mortality at reserve sites, but also provide useful data beyond what is collected during the course of regular survey operations. It is important to note that the release of live specimens will preclude the collection of biological data on age, diet and maturity. The CINMS and NWFSC will collaborate to determine the impact of the loss of these data on applications including stock assessments, life history research, and the ability to monitor the population dynamics within the reserves.

Survey vessels are currently required to carry fish descending devices, and survey staff used them on an experimental basis during the 2014 survey. Our experience suggests that the descending devices that are currently available are: 1) labor intensive, requiring an additional dedicated biologist or deckhand per descending device in use; and, 2) designed primarily for use during passenger fishing trips (where anglers typically use single or 2-hook gangions and capture smaller fish in waters generally shallower than those sampled on the survey). Consequently, they are not suitable for descending fish of the size and at the rate and depths they are caught on the survey. Given these conditions, the likely result from their expanded use during the survey is that many, if not most, descended fish will have little chance of survival.

A more suitable approach would be to develop a system that allows for the continued collection of basic biological data (e.g., species, length, weight, sex, etc.) and maximizes the likelihood of survival for captured specimens. We propose developing and building a custom device that can temporarily hold fish at the surface after basic biological data is collected from each fish captured during a sampling drop (up to 15 adult fish) and then descend all specimens to depth *en masse*. This approach not only supports the historical consistency of established sampling protocols, it also facilitates the collection of additional data useful to both the CINMS and NWFSC such as the integration of a mark-recapture study and evaluating the short-term mortality of descended fish by affixing an underwater video camera within the descending cage to capture visual observations of the descending process. Upon mutual determination that this approach adequately mitigates survey mortality within the reserves, survey effort will return to historical protocols of 5 sampling drops per site. We propose the following timeline for implementing descending devices:

- Summer 2015 – June 2016: Research, design, and construct a multi-fish descending device and all equipment necessary for its deployment including the *in-situ* holding cage, a winch or other means to deploy and retrieve the device, and a video system to monitor evaluate the behavior of the descended fish. In addition, staff will research the most appropriate protocols and design for the integrated tagging study. These steps will include an extensive literature review and consultation with industry and other fisheries scientists for effective approaches.
- Fall 2015: If possible, test components of the novel device on board chartered survey vessels. Continue experimentation with traditional descending devices; tag and descend 1-3 individuals at MPA sites when possible.
- Winter - Spring 2016: Develop a comprehensive plan that incorporates the new descending device and the mark-recapture project. Work with CINMS staff and the local sportfishing industry to develop an outreach plan to the recreational fishing community to maximize tag return.
- Spring 2016: NWFSC will report on progress and results to date to CINMS. If appropriate, CINMS and NWFSC will work together to apply for funding for further development and testing of devices, and discuss opportunities for increased (joint) staffing to allow devices to be deployed efficiently.
- Summer 2016: Test the newly developed system, adjust as appropriate. Report results to CINMS.
- Fall 2016: Deploy the newly designed descending device capable of handling 15 fish at a time (the maximum potential catch per drop) in CINMS reserves.
- If deployment of the new descending device is delayed for any reason, CINMS and NWFSC staff will consult on appropriate mitigation actions until issues can be resolved.

Part IV. Developing Additional Scientific Information for Fisheries and Sanctuary Use

Annual check-ins

The NWFSC is committed to an ongoing partnership with CINMS on research issues of mutual interest. We believe sampling associated with the hook and line survey represents an exciting opportunity to help understand the particular dynamics of the CINMS and its marine reserves while improving the stock assessments that are used to manage important species of groundfish. Further, we believe the survey represents only a starting point, rather than ending point for potential research collaboration and look forward to exploring many other interesting ideas for studying this unique area in the near future. To help ensure direct lines of communication remain open, the NWFSC proposes an annual, in-person meeting with CINMS to present the results of the survey and of relevant research and discuss areas of concern. This meeting may include the following:

- Presentation and discussion of analysis and metrics that can be used to assist the CINMS in monitoring MPAs (e.g., catch at reserve sites, catch at all CINMS sites, catch outside CINMS, length frequency analysis of indicator species inside and outside reserve sites, etc.).
- Discussion of potential changes in survey plans based on results of previous year's research.
- Discussion of future joint research (see also below).
- Presentation and discussion of subsequent year's work plan.
- Identification of potential funding sources to support additional research, vessel charter time, and project development
- Other topics as determined jointly two months before the meeting (allowing adequate preparation time).

Identification of potential new research areas

The NWFSC's hook and line survey offers many opportunities for the NWFSC and the CINMS to improve our understanding of the sanctuary itself as well as the living marine resources that use its waters. We propose that CINMS and the NWFSC staff work together to prioritize the following potential areas of work:

- Using hook and line survey data and specimens to understand the ecological impacts of these marine reserves in particular, as well as general attributes of marine reserves. This could include comprehensive analysis of existing data as well as new projects.
- Sanctuary-driven research projects that would include CINMS staff as research partners and survey participants.
- Improving the quality of habitat maps available for CINMS waters. The NWFSC's camera sled provides real-time video footage of the seafloor which can be used to ground-truth multibeam mapping data and improve the algorithms used to determine habitat type from backscatter. Improved habitat maps will in turn better inform abundance estimates calculated using survey CPUE data.
- Developing novel non-lethal survey methods within reserves.
- Using mark-recapture data and potentially stable isotope analysis to study the ontogenetic movement of key groundfish species at the scales of the individual reserve, entire CINMS, and the SCB as a region. This can shed light on what habitat types are most important to different life history stages and improve our understanding of population dynamics in the region.
- Using the suite of oceanographic data (e.g., temperature, salinity, dissolved oxygen, turbidity, and chlorophyll) collected during each survey site visit to improve our understanding of the role these parameters play in presence/absence of key species, relative abundance, and how populations respond to short- and medium-term changes in oceanography including short-lived algae blooms, El Nino events, and seasonal oceanographic anomalies.

- Integrating all of this into a more holistic analysis of how habitat, oceanography, abundance, and basic demographic data interact to drive the population dynamics within the CINMS and SCB.

After priorities have been established, the CINMS, NWFSC, and appropriate partners will develop a work plan to review and implement key studies. Some studies, such as those evaluating the impact of marine reserves, are likely to require a workshop and/or independent review to develop appropriate and statistically robust methodologies and approaches. In addition, due to limited resources, CINMS and NWFSC staff most likely will need to submit proposals to augment available funding to support this work.

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